Wilson Bull., 93(3), 1981, pp. 438–456

REPORT OF THE CONSERVATION COMMITTEE—1980

1980, The Year of the Coast: Birds

Thousands of kilometers of undulating coastlines rim the U.S. from Washington to Maine, the Hawaiian Islands and the Alaskan Peninsula. These are fragile environments—whether arctic, temperate, or tropical—yet man and his exploitative energies despoil coastal resources unrelentingly. Historically, man has concentrated cities, commerce and recreation on coastlines that today are immense centers of human activities. Some estimates place four of every 10 industrial facilities on the nation's coast, and the ugly sores of waste disposal are all too commonplace. Drainage schemes or landfills modify our coastal endowment. Estuaries reflect the chemical and physical abuses of their upstream sources and, beyond land's end, flows the garbage of human carelessness. Tidal ecosystems are self-maintaining only so long as man does not upset the delicate balance that has evolved over the centuries. Man may claim selected areas for his own needs as long as other tracts remain undisturbed by intrusion and pollution; but this can be accomplished only with careful long-range planning. Our coasts are choking under the pressures of their own magnetism.

In their pristine condition, our coasts harbored ecological "goods and services" beyond our current imagination. Today, the richness of their species and functions is regrettably diminished. In southern Florida alone, waterbird populations have declined from 2.5 million in 1870, to 1.5 million in 1935, to 150,000 in 1974. Although early losses can be attributed to "plume hunting," declines in the past 60 years are the result of man's destruction of feeding and nesting habitat (Soots and Landin 1978).

For many birds, coastlines are requisites for nesting and feeding; still other species seek freshwater environments for breeding but tap the rich resources of the coastline during migration and wintering periods. Freshwater birds wintering on seacoasts employ various strategies. Many use any stretch of sand, gravel, or rocky shore that harbors suitable foods. Others use restricted topographical and/or ecological situations that provide protection as well as special foods (e.g., Brant, *Branta bernicla*, and eelgrass, *Zostera marina*).

Seabirds are not without adaptability. Some feed at sea, ranging over wide areas so that patchy food resources are used where they occur. Some pioneer nesting sites on islands or coastlines, precluding endemic status. Conversely, some features of seabirds potentially limit their success in a rapidly changing world. Many have low reproductive rates with delayed maturation, or experience considerable competition for nesting sites.

Nesting sites for seabirds often are uniquely situated. Some birds use rocky cliff edges or crevices where nesting sites are limited but where the nests also are well protected from predators and man. Conversely, beach sites are more available but remain vulnerable to human disturbances. Moreover, many species have proven especially sensitive to man-made disturbances because of their specialized behavioral responses to potential predation.

Offshore, uses of seacoasts are less observable, but there birds feed on schools of fish and plankton in shoal and other areas that may be especially vulnerable to pollution and concomitant loss of basic productivity. Coastal regimes represent one of our planet's more complex energy-flow systems, and, with their continued abuse, "The coast is informing us that there is a saturation point beyond which its natural functions no longer flourish, often diminish, or simply cease" (Simon 1978). With 1980 designated as the Year of the Coast, we focus on a major component of coastal systems to illustrate the national concern for natural resources—birds of the American coastline.

Geographical Review

West Coast.—The West Coast of the United States extends approximately 2750 km from the Mexican border to the Straits of Juan de Fuca in the north. This extensive mainland and island coast includes some of the richest seabird habitats found anywhere in North America. In addition to the resources of the open sea, the western coastline is interspersed with seacliffs, beaches, bays, estuaries, tidal mud flats and saltwater marshes. Four geographic areas characterize this diverse coastal environment: southern California, San Francisco Bay, Columbia River Estuary and Puget Sound in Washington.

The seacoast of southern California supports about 158 species of birds (Corwin and Heffernan 1978). Most of these sea- and shorebirds are strongly migratory, and the largest number of individuals and species are found during the autumn and spring migrations. The most abundant species during migration is the Sooty Shearwater (*Puffinus griseus*). During autumn migration, tropical seabirds such as the Magnificent Frigatebird (*Fregata magnificens*) and the Red-billed Tropicbird (*Phaethon aethereus*) which are of infrequent occurrence so far north appear along the southern California coast. Partially responsible for these occurrences is the Davidson Current, a counter-current between the coast and the cool California Current from the north-central Pacific Ocean (Small 1974).

Along the southern California coast, the continental shelf is narrow; instead, a series of ranges and basins exists. Close to these submarine banks strong northerly winds displace the surface waters, especially during May and June. The result is an upwelling of deep, cold waters rich in nutrients and dissolved oxygen, fostering a proliferation of phytoplankton—the base of virtually all marine food-chains. The abundance of pelagic birds such as jaegers (*Stercorarius* spp.), storm-petrels (Hydrobatidae) and albatrosses (*Diomedea* spp.) is related to the surface concentrations of zooplankton, schools of surfacing anchovies and spawning squids (Small 1974).

Extending from Los Angeles to Point Conception are the eight Channel Islands. During the Pleistocene, these islands were part of an archipelago associated with the continental landmass; subsequent deformation of the earth's crust and changes in sea level separated them from the mainland (Casey 1969). Two of the islands, Anacapa and Santa Barbara Island, are parks within the Channel Islands National Monument, but most of the offshore islands are relatively inaccessible to the public. Thus, nesting and roosting seabirds such as the Xantus' Murrelet (*Endomychura hypoleuca*), Cassin's Auklet (*Ptychoramphus aleutica*) and the Brown Pelican (*Pelecanus occidentalis*), an endangered species, remain undisturbed. In 1969, nesting colonies of Brown Pelicans produced almost no young because of eggshell breakage; DDT interfered with enzyme production involved with calcium mobilization from bones to egg shells (Small 1974). A major source of contamination was discharge from a Los Angeles plant that manufactured technical DDT. After 1970, this plant's liquid wastes were put in a sanitary landfill and the oceanic input of DDT declined. When DDE contamination of the birds' major food source, anchovies, declined, hatching of pelican eggs increased significantly but productivity has remained low (Anderson et al. 1975).

Besides large offshore islands, the southern California coast is characterized by sandy beaches (75% of the coast). Furthermore, the climate south from San Francisco is Mediterranean with three months of winter rains followed by a hot, dry summer. These favorable conditions make southern California a major focus of the state's human population, and thus, of recreation and economic development. Large population centers in southern California have altered the coastal habitat considerably. For example, of the vast wetlands along the Los Angeles County coast, only 110 ha remain. Dredging and filling have been the primary causes of this habitat destruction (Corwin and Heffernan 1978).

Along these sandy beaches two species breed, the California Least Tern (*Sterna albifrons browni*) and the western race of the Snowy Plover (*Charadrius alexandrinus nivosus*). At the

turn of this century the Least Tern was an abundant colonial nester along the seacoast from the Mexican border to San Francisco Bay. However, human activities reduced this population to such a low level that, by 1966, the California Least Tern was declared an endangered species. Plovers have not declined similarly, probably because of a broader breeding range (southern Washingon to southern Baja and inland); they also nest further back from the beachfronts (Small 1974).

Prospects of large discoveries of oil and gas on the California coast are favorable, whereas the Oregon-Washington coast has the least potential for petroleum development of any region considered by the Department of Interior's accelerated leasing program (Feldmann and Hershman 1978). It was under this program that portions of the Santa Barbara Channel were leased in 1968. On 28 January 1969, a well at Union Oil's Platform A blew out. As a result, 12.3 million liters of oil coated 1710 km² of channel, 160 km of shore were contaminated and an estimated 8000 seabirds died (Dedera 1970). The risk of oil spills will only increase as more tracts are leased for development. Unfortunately, the rookeries of South Anacapa Island are especially endangered because of their proximity to shipping lanes (Corwin and Heffernan 1978).

San Francisco Bay originally consisted of 1814 km², but now only 1165 km² remain (Knight 1972). The ability of the Bay to flush its waste loads has been reduced both by filling and by the diversion of the Sacramento River to southern California, cutting the river's flow into the Bay by 50% and seriously affecting the estuarine balance between salt and fresh water. Further alteration has been caused by the estimated 3.2 billion liters of waste water entering the Bay each day (Knight 1972). The remaining portions of the San Francisco Bay consist mostly of mud flats with a few pocket beaches and marshes. Tidal salt marshes are characterized by cordgrass (*Spartina foliosa*), pickleweed (*Salicornia* spp.), saltgrass (*Disticlis spicata*) and gumplant (*Grindelia* spp.). These salt marshes are used by most migrant shorebirds such as Willets (*Catoptrophorus semipalmatus*) and Marbled Godwits (*Limosa fedoa*) as roosting areas at high tide; during ebbtide the exposed mud flats become important feeding areas (Page et al. 1979). A resident species that uses salt marshes almost exclusively is the California Clapper Rail (*Rallus longirostris obsoletus*), an endangered species. This rallid once occupied most estuarine marshes of central and northern coastal California. After 1900, a significant decrease in range and numbers resulted from habitat loss (diking, filling or conversion of salt evaporation ponds) (Gill 1979).

Forty-three km west of San Francisco Bay are the Farallon Islands. Because of commercial egging in the 19th century, these small islands were declared a wildlife refuge in 1909. The Farallon Islands today contain the largest seabird colonies in the contiguous U.S. (Small 1974). Just northwest of San Francisco is the Point Reyes Peninsula, the West Coast's only National Seashore.

In Oregon and Washington the proximity of the Coast Range to the coast limits the area available for development. Furthermore, the maritime climate along this seacoast produces rainy winters (as much as 254 cm of annual rainfall) and cool, dry summers. Despite low population densities along this coast, the harbors and coastal ocean have been subject to contamination. Waste chemicals and paper mill wastes in certain estuaries cause severe pollution locally.

Of the 14 estuary systems along the Oregon coast, the Columbia River is the largest with 6075 ha. Relatively little mixing of salt and fresh water occurs in this estuary. In fact, during summer and fall it is the largest source of fresh water along the entire West Coast of the U.S. The Columbia River is an important wintering area for waterfowl. The largest concentration of Mallards (*Anas platyrhynchos*) along the Pacific Flyway occurs in the Columbia Basin. Irrigated grain farms provide an important food resource for this large population (Bellrose 1976).

Puget Sound encompasses 647,775 ha, the largest estuary in Washington. During the

spring, Puget Sound is an important breeding area for pelagic species. Puffins (Alcidae), Rhinocerous Auklets (*Cerorhinca monocerata*) and Pigeon Guillemots (*Cepphus columba*) dig burrows in cliffs and banks near the saltwater beaches of the Sound. In the fall about 10 million ducks and 1 million geese use the Pacific Flyway. Puget Sound, with its extensive shores and shore water estuaries, mud flats and marshes, is protected from direct marine influence by the Olympic Peninsula and thus provides feeding and resting areas for these waterfowl (Feldmann and Hershman 1978).

Ports on Puget Sound are prizes for the oil industry as Alaskan petroleum resources develop. Increased tanker traffic will further increase the risk of oil spills damaging the substantial resources of the Sound. For example, Puget Sound has five National Wildlife Refuges, four of which lie along an important oil-tanker route through Rosario Straits.

East Coast.—The Atlantic coast of the United States and Canada is used heavily by a great variety of sea- and shorebirds at all seasons of the year. The sea cliffs of eastern Canada are famous for their colonies of gannets, cormorants, gulls and alcids, the marshes of the Middle Atlantic States for their wintering waterfowl, and the islands and wetlands of the Southeast for their colonies of herons, pelicans and terns, and hordes of wintering shorebirds (Fig. 1).

The Atlantic Ocean has a modifying influence on the coastal climate. In the coldest weather the immediate coast from Georgia to Maine is about 5°C warmer than a few miles inland and the frost-free period is 20–40 days longer. Mean annual temperatures range from 24°C in South Florida to 6°C in eastern Maine, and mean annual precipitation from 110 cm in Maine to 150 cm in South Florida (Visher 1954). Add to this the higher average relative humidity, the greater annual precipitation and higher percentage of sunshine (Visher 1954) and it becomes clear that this is an area of high productivity.

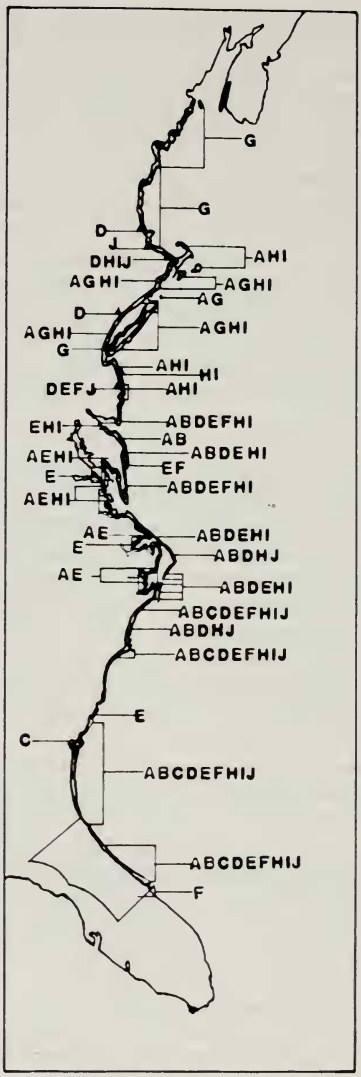
In the Mid-Atlantic Bight alone (Nantucket to Cape Hatteras), the commercial fisheries yield about 31,800 metric tons of fish and shellfish per year at a value of $70 million; and 2.5 million saltwater anglers in 1970 generated more than $318 million of business activity (Saila 1973).

As early as the colonial period the potential value of tidal marsh for agriculture and other uses was recognized, and extensive areas of tidal marsh in the Carolinas and Georgia were reclaimed for rice production (Knights and Phillips 1979). Reclamation for living space, recreation and industry has continued at an increasing pace and to these activities have been added pressures from mining, oil production, transportation, fishing, military uses, waste disposal and other direct and indirect sources of pollution that threaten the survival of not only the coastal ecosystem, but the future of our planet's living oceans. Senator Ernest F. Hollings (*in* Edge 1972), citing testimony from Jacques Cousteau, stated that life in the sea during the past 20 years had diminished as much as 30–50%.

Bird life along the Atlantic coast is rich and varied at all seasons. Saila (1973) listed 380 species from the coastal lands and offshore waters of the Mid-Atlantic Bight. Colonial nesting species have been well documented in recent years by Brown et al. (1975), Osborn and Custer (1978), Erwin (1979), Erwin and Korschgen (1979), Parnell and Soots (1979), and others.

From Massachusetts east through the Maritime Provinces, the petrels, gannets, cormorants, ducks, gulls, terns and four species of alcids nest high on rocky islands, beyond the reach of storm tides. Nevertheless, many species lead a perilous existence because of gulls and other predators and are not prepared to stand the stress of further disruption of nesting activities by human intervention.

Stretches of undisturbed beach are needed by two species of breeding plovers. Islands free of mammalian predators and human disturbances are essential for the nesting of 10 species of terns, and three of gulls (*Larus*), as well as for cormorants (*Phalacrocorax*), oystercatchers (*Haematopus*) and skimmers (*Rynchops*). Along the Middle and South Atlantic



Shorebirds : Winter Distribution

A	American Oystercatcher	G	Purple Sandpiper
B	Piping Plover	H	Dunlin
C	Wilson's Plover	I	Sanderling
D	Black-bellied Plover	J	Short-billed Dowicher
E	Willet	/	Major Winter Distribution
F	Lesser Yellowlegs	▲	Fall Migration Concentration Area

coasts many of these birds nest barely above high tide where their eggs are subject to mass destruction by storm tides; and a single visit by human intruders can also wipe out an entire year's production.

The great tidal marshes that stretch intermittently from New Jersey and Chesapeake Bay south to Florida are vital to nesting of Willets, Clapper (*Rallus longirostris*) and (locally) Black (*Laterallus jamaicensis*) rails, and Sharp-tailed (*Ammospiza caudacuta*) and Seaside (*A. maritima*) sparrows as well as to several kinds of gulls and terns. These marshes also serve as nurseries for much of the aquatic life on which the offshore fisheries depend (for humans as well as birds).

From mid-summer into mid-autumn, the coastal flats and marshes support vast hordes of migrating shorebirds en route from their Arctic nesting grounds in Canada to their winter homes in Latin America. In preparation for long non-stop flights over water, these millions of migrants require extensive unpolluted feeding grounds. For the shorebirds, waterfowl, cormorants and pelicans wintering along the Atlantic coast unpolluted coastal waters are essential. And for the gannets (*Morus*), kittiwakes (*Rissa*), fulmars (*Fulmarus*), skuas (*Catharacta*), jaegers and alcids that winter in our offshore waters, a clean environment also must be maintained.

The changing ecology of Chesapeake Bay, if not typical of trends along the Atlantic coast, may at least be symptomatic, and underscore the need for closer monitoring of habitat conditions in all coastal bays. Stevenson et al. (1979) have shown the sharp decline in submerged aquatic vegetation from 1971–1978. Using data from more than 600 sites, the percentage of stations with aquatic grasses decreased from 28–10%, and there was a comparable decrease in diversity. No single cause for this change could be proven, but contributing factors considered of minor or local importance were overgrazing by carp, cownose rays and Mute Swans (*Cygnus olor*), effects of Hurricane Agnes (in June 1972), warming trends of Bay waters, natural diseases, point-source pollutants, petrochemicals, dredging, and boat traffic. Possible major contributing factors were chlorine (about 13,200 metric tons entered the Bay in 1973), increasing levels of turbidity in shallow waters, excessive nutrients (phosphorus and nitrogen) from waste water, a dramatic increase in herbicides, and locally, competition from water chestnut (*Trapa natans*) and Eurasian watermilfoil (*Myriophyllum spicatum*).

Effects on wintering waterfowl from the loss of submerged aquatic plants have been summarized by Perry et al. (1981). Wintering waterfowl numbers have declined 50%, with only the Buffleheads (*Bucephala albeola*) showing increases. Species feeding predominantly on submerged aquatics have been affected the greatest. There has been a decline in the diversity of estuarine food organisms available and in the percentage of vegetation eaten by the ducks. Submerged aquatic vegetation is no longer a major food for Canvasbacks (*Aythya valisineria*) and Ruddy Ducks (*Oxyura jamaicensis*) wintering in Chesapeake Bay.

An example of the inadvertent loss of an endangered bird from habitat alteration in a coastal marsh is provided by the Dusky Seaside Sparrow (*Ammospiza maritima nigrescens*). Sharp (1970) contrasted the 33–34 males he found at Merritt Island, Brevard Co., Florida, in 1968, with the 70 pairs he found there in 1963, and with an indirect estimate of about 600 pairs in 1957. Annual censuses by Sykes (1980) in 1969–79 revealed 30, 18, 8, 11, 2, 2, 2, 0, 2, 0 and 0 singing males in this area. Sharp (1970) estimated a total (world) population of 894

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FIG. 1. Winter distribution of shorebirds on the eastern U.S. coastline. Redrawn from an original map courtesy of National Oceanic and Atmospheric Administration. The Conservation Committee notes that certain winter distributions (e.g., American Oystercatcher) located north of Virginia may not be typical.

males in 1968, primarily in the St. John's River marshes. The last remnants of this population were 13 males in 1979 and 4 males and no females in 1980 (Sykes 1980). All except one male have been taken into captivity in an effort to produce a nearly pure population through backcrossing, using 2 female *nigrescens* × *peninsulae* hybrids produced in 1980 (Sykes, pers. comm.).

Causes of the final decline at Merritt Island, summarized by Sykes (1980) include elimination of about 91% of the former habitat by impounding and flooding, invasion of shrubs (and probably predators) along the dike system, and an increase in Red-winged Blackbirds (*Agelaius phoeniceus*) because of the increase in shrubs. Management activities, including dike removal and periodic burning, were undertaken in an effort to restore the habitat to its original condition, but not in time to be effective.

On the brighter side, the successful reintroduction of Common Puffins (*Fratercula arctica*) on Eastern Egg Rock in Maine (Graham 1976) demonstrates that, given sufficient knowledge, interest and support, we have the opportunity to retain important features of coastal systems.

The Gulf Coast.—Coastal habitats along the Gulf of Mexico are probably best known as wintering grounds for a large percentage of North America's waterfowl population. But in addition to providing seasonal habitat for ducks and geese, the extensive wetlands along the Gulf Coast support large migratory and resident populations of shorebirds, wading birds and other wetland species.

Climatic conditions along the Gulf Coast are somewhat varied. The growing season is long and the winter is usually mild. Summer temperatures and humidities, which are generally high, favor luxuriant vegetative growth. Precipitation is variable, but averages over 125 cm per year in all coastal areas except extreme south Texas. Rainfall is less than 80 cm per year in southern Texas and the area is semi-arid.

The southern tip of Florida is classified as a humid tropical savannah (Bailey 1978). Mangrove swamps are common in the Everglades and Florida Keys. Mangroves produce large amounts of detritus, providing the basis for food webs in the swamps. These swamps provide habitat for countless terrestrial and aquatic animals, particularly birds (Hanlon et al. 1975).

Salt and freshwater marshes are common along the upper Gulf Coast. Marshes and marsh vegetation produce large amounts of detritus that are exported from the marsh into adjacent bay waters. Kirby and Gosselink (1976) estimated 70% export of the net production from the marsh they studied; production for a Louisiana Gulf Coast salt marsh was estimated as 1176 $g/m^2/yr$. It is well documented that marshes serve as nursery grounds for commercially important fin-fishes and shellfishes. Marshes are also important habitats for migratory birds. For example, almost the entire North American population of the Lesser Snow Goose (*Anser c. caerulescens*) is dependent upon the marshes on the Louisiana and Texas coasts for winter habitat (Gosselink et al. 1974).

Barrier islands are found along many parts of the upper Gulf Coast but are most well-developed in Texas. Barrier islands have several ecological values: the dune systems protect landward areas from storm wave and tidal damage; the islands form and protect productive estuaries on the landward side; and the islands support a unique flora and fauna. In past times the barrier islands were significant nesting habitats for colonial waterbirds, especially terns and Black Skimmers (*Rynchops nigra*) (Portnoy 1977, Chapman 1980). Human encroachment has caused a drastic decline in the use of the Texas barrier islands as nesting habitat (Chapman 1980); the decline is not as drastic in Louisiana (Portnoy 1978).

In shallow bay waters at depths up to 1.5 m extensive beds of submerged seagrasses are common on the Gulf Coast. The sediments of seagrass systems perform similar functions to those of tidal marshes. Seagrass systems provide wildlife habitat and serve as spawning grounds for many marine organisms. The Laguna Madre, a 202 km long lagoon with extensive seagrass beds in southern Texas, provides rich feeding habitat for birds. In addition to large concentrations of shorebirds and wading birds, 78% of the North American population of

Redheads (*Aythya americana*) winter in the Laguna (Weller 1964). Many waterfowl use the Central Flyway, including 80% of the Pintails (*Anas acuta*), 90% of the Northern Shovelers (*A. clypeata*), 98% of the Red-breasted Mergansers (*Mergus serrator*) and 43% of the Bufleheads also winter there.

Large nesting populations of seabirds and wading birds occur along the Gulf Coast. Portnoy (1977) found 168 colonies totaling more than 847,000 breeding birds of 26 species in the coastal areas of Louisiana, Mississippi and Alabama; Chaney et al. (1978) counted more than 257,000 breeding birds of 28 species nesting along the Texas coast. Most of the colonial waterbirds in Texas nest upon dredged-material islands.

Populations of most colonial waterbird species have been declining in recent years in Texas (Chapman 1980); reliable information on population trends is not available for most of the northern Gulf Coast (Portnoy 1980). Although there are many factors that have contributed to the decline, two are probably of major importance—pesticide contamination and habitat alteration.

Before 1920, populations of Brown Pelicans were estimated at 50,000–85,000 birds in Louisiana and 5000 in Texas. The last record of nesting Brown Pelicans in Louisiana was in 1961 (Van Tets 1965) and the Texas population declined to about 100 by 1974 (King et al. 1977). Weather and disease also may have contributed to the decline of Brown Pelican populations, but there is significant evidence that pesticides contributed to the pelican decline.

Effects of habitat alteration are more difficult to assess because the changes are often subtle and may involve an alteration of the food web rather than direct avian habitat loss. For example, there is abundant nesting habitat in Texas on dredged-material islands (Chaney et al. 1978), but waterbird populations are declining as are fishery stocks in the bays. Most development of wetland habitat contributes to declining avian populations.

Hawaiian Islands.—Isolated in the Central Pacific at 19°–29°N latitude, the Hawaiian Islands span about 2400 km from the largest and most easterly island of Hawaii to the smaller Midway and Kure atolls to the west. The 10 larger Windward Islands are well known to tourists, but among the 30 or more islets, reefs and volcanic pinnacles making up the Leeward Islands are the most unique tropical seabird habitats of the U.S. Many of the Leewards were among the earliest additions to the National Refuge System in 1909.

The Hawaiian Islands are ornithologically distinctive for their many and often rare forest endemics, their evolutionary offshoots from surrounding continents and for their several species of threatened or endangered waterbirds. But the extensive and varied coastal areas serve many birds, including nesting seabirds and migratory shorebirds.

The indigenous seabirds include two albatrosses, two shearwaters, three petrels, two storm-petrels, two tropicbirds, three boobies (*Sula*), one Frigatebird (*Fregata minor palmerstoni*), six terns and noddies, and 13 other procellariiforms or pelecaniforms that are migratory visitors or stragglers. Not only do these resident birds nest on the sand and cliff shorelines, but some endemic races move inland where they nest in peaty burrows (the threatened Newell's Shearwater [*Puffinus puffinus newelli*]) or rocky burrows at elevations up to 2900 m (the endangered Dark-rumped Petrel [*Pterodroma phaeopygia sandwichensis*]). The smaller Leeward Islands are the major nesting areas for several species of seabirds that are present in tens of thousands. Best known of these are the Black-footed (*Diomedea nigripes*) and Laysan (*D. immutabilis*) albatrosses, which once nested on numerous other Pacific Islands and presumably were disturbed by human activities, just as a pioneering colony of Laysan albatrosses now is being affected on Kauai.

Five species of shorebirds regularly winter in Hawaii, and 33 have been recorded there enroute to more southerly islands and continents. However, the commonest (Golden Plover [*Pluvialis dominica fulva*]) and rarest (Bristle-thighed Curlew [*Numenius tahitiensis*]) tend to use upland areas or freshwater shorelines, respectively. Several widespread species use

the seashore, including Ruddy Turnstones (*Arenaria interpres*) and Sanderlings (*Crocethia alba*). No species of gulls are regular winter visitors, although numerous continental gulls and terns have been sighted or collected in Hawaii.

The historical use of coastal areas by birds is not well known, but there are examples suggesting that it once was much greater on the larger, now-inhabited, Windward Islands. Human disturbance has discouraged nesting in several areas in recent times, but some re-establishment has occurred. Land-use planning, pollution control and protection are particularly essential to the ecological maintenance of Hawaiian coastlines with high bird populations.

Alaska.—Because of its size and configuration, Alaska has diversity in climate and topography that influences how birds use coastal habitats. The northern Beaufort Sea coastline has severest climate in the region, with the sea being partially open only 6–10 weeks a year, and all but a few terrestrial species move south after breeding. The southeastern coast and the Aleutians have climates moderated by the sea, and although severe, they provide wintering areas for a variety of coastal seabirds and ducks supported by nutrient-rich, cold waters.

Alaska's geomorphology offers diverse coastal habitats for birds. Coastal wetlands may constitute 25–50% of the area of the Coastal Plain. Extensive lagoons formed by the dynamic shorelines and bars of the Arctic Ocean, and Izembak Lagoon of the Alaska Peninsula, harbor most of the Brant (*Branta bernicla nigricans*) of western North America during post-breeding periods and spring migration.

Huge river deltas such as the Yukon-Kuskokwim rivers of west-central Alaska and the Copper River delta of the south form extensive wetland habitats on land and enrich extensive marine areas. Both are extensively used by Brant, shorebirds and other near-shore species. Rugged cliffs of the southern coasts and many offshore islands (Pribilof, Aleutian, St. Lawrence and Kodiak islands) offer diverse nest-sites for alcids, kittiwakes, gulls and cormorants.

The southeast coast and fjordland is one of the most complex shores in North America because of the offshore islands that form a protected coastal waterway. Not only are these areas excellent for a variety of seabirds and shorebirds, but coastal fisheaters like eagles, ospreys and gulls are prominent.

The Alaskan avifauna is dominated by birds that use the coast during migration as well as breeding, and includes numerous seabirds. There are two phalaropes (Phalaropodidae), two grebes (Podicipedidae), four loons, (*Gavia*), one fulmar, three cormorants, two storm-petrels, more than 30 waterfowl, six shearwaters, two petrels, two albatrosses, three jaegers, 15 or more gulls, kittiwakes and terns, 16 alcids (including six auklets), and more than 40 shorebirds, including some Asian migrants. Large marine bays favor concentration of Southern Hemisphere shearwaters that spend the southern winter in the north. Bristol Bay is regarded as one of the greatest known concentrations of seabirds, numbering annually in the millions, and the Gulf of Alaska is a gathering area for migrants of many kinds. Offshore waters are especially important for Southern Hemisphere seabirds that migrate from the New Zealand–Australia area to the Gulf of Alaska: Slender-billed Shearwater (*Puffinus tenuirostris*) and Sooty Shearwater.

Coastal disturbance and modification, until recently, have been mostly confined to the southeastern coasts where timber, fishing and mining interests have increased activity and modified habitats. Beginning in the 1960's, exploration for, and development of, oil fields in the Cook Inlet and the Beaufort Sea have produced some pollution and habitat modifications.

Coastal Wildlife Resources.—Increasing focus on barrier islands, estuaries and sounds followed President Carter's environmental message in May 1977. In it he called for an effective plan to improve protection for Atlantic and Gulf Coast barrier islands and their associated aquatic and terrestrial habitats. Subsequent efforts produced a draft report (U.S. Dept. of the Interior 1979). It shows there are about 295 barrier islands, ranging in size from

less than 20 ha to more than 40,400 ha, from Maine to Florida and along the Gulf of Mexico to Texas. About 200 of these islands, totaling 98,400 ha, have some developments, while 95 are undeveloped. The 295 islands in 108 counties of 18 coastal states total about 648,000 ha, of which approximately 261,200 ha are managed by federal (177,600 ha), state (72,000 ha), or local (11,900 ha) governments and private conservation organizations. Of the 251,000 ha, the U.S. Fish and Wildlife Service administers 31 National Wildlife Refuges totaling 157,000 ha that contain nearly 300 km of beach in 12 coastal states from Maine to Texas. About 389,000 ha are in prviate ownership and are unprotected from future developments.

Approximately one-half of the 648,000 ha is wetland, one-quarter is barren, and one-quarter is urbanized. Because of heavy demands for development of primary and secondary home sites and recreation resorts, the barrier islands are urbanizing at a rate twice that of the nation as a whole. This unprecedented growth in wind- and water-hazardous locations is (1) exposing the owners' personal properties to high risk of damages; (2) increasing the potential for enlarging taxpayer-funded disaster relief payments; (3) usurping and continuing to threaten essential aquatic and terrestrial habitats of plants and animals; and (4) compounding pollution problems.

The estuaries and sounds protected by barrier islands from ocean winds and waves are among the most productive and richest ecosystems known. They provide nesting, resting and feeding areas for a broad spectrum of birds and mammals, as well as spawning, nursery and feeding grounds for a wide variety of fin- and shellfish. Because of their importance to the nation as natural resources and because of growing demands for housing, recreation and petroleum developments, the Office of Coastal Zone Management and the Council on Environmental Quality, jointly, have produced a data atlas on the eastern United States coastal and ocean zones (Ray et al. 1980). Each of approximately 125 maps provides information organized in five categories: (1) physical environments, 13 maps; (2) living environments, five maps; (3) distribution and status of animal and plant species, 68 maps; (4) economic activities, 29 maps; and (5) jurisdictional boundaries, and management and protected areas, 10 maps. The objective of the atlas is to identify East Coast areas least suitable for major energy and other developments, as well as areas that should be analyzed on a site-specific basis for possible special protection status because of their biological and ecological importance. Shorebird wintering areas are one example of important habitats to receive careful evaluation and consideration.

Current plans of the Office of Coastal Zone Management call for preparing similar atlases for the entire Gulf of Mexico and Beaufort, Chukchi and Bering seas off Alaska by 1982. Further information on these plans, as well as copies of the East Coast atlas, can be obtained from the Office of Ocean Resources Coordination and Assessment, Office of Coastal Zone Management, National Oceanic and Atmospheric Administration, Washington, D.C. 20235 (telephone 202/634-4120).

Environmental Perturbations

Dredging Activities.—Dredged material (= spoil) by the millions of cubic meters is removed each year in the creation and maintenance of channels in wetland habitats. Additionally, dredging is employed in the construction of harbors and marinas, in pipeline rights-of-way, and for obtaining fill or building materials (La Roe 1977).

Dredging activities and the subsequent deposition of spoil can affect adversely the coastal ecosystem in many ways. Dredging may alter water current patterns, rates of water circulation, change mixing and flushing patterns and affect salinity levels. Further, the removal, transportation and deposition of sediments often produce large quantities of silt that remain suspended in the water column; the larger sediments settle rapidly, but the finer particles may be carried great distances over extended periods of time.

Suspended silt can smother bottom-dwelling plants and animals; it can clog the gill structures of fish. High turbidities reduce vision and can mask odors, thus affecting the welfare of aquatic species. Most invertebrates, especially filter-feeders, cease feeding under a regime of high turbidity. The silt suspended during dredging operations decreases light penetration into the water, thus reducing photosynthesis and basic productivity.

Estuarine sediments, which generally have a high organic content, are aerated by the roots of marine seagrasses, but fine silts can smother plants and seal the bottom. Once this happens, the upper sediments become anaerobic and may produce toxic hydrogen sulfide deposits. The anaerobic sediments and increased biochemical oxygen demand (BOD) in the water column caused by suspended organic matter also can accentuate the reduction of dissolved oxygen in the vicinity of dredging operations.

Under normal conditions, marine seagrasses and tidal marshes are not only productive habitats for birds and other wildlife, but they also provide other benefits. These habitats prevent erosion by stabilizing emergent and submergent sediments. They also act as an efficient filtration system that maintains water quality. Removal or destruction of vegetative associations in wetlands induces instability throughout the aquatic system.

Dredging also produces material that requires disposal. Habitat is affected two ways: (1) bottom habitat is removed; and (2) the material is deposited over bottom or terrestrial habitats elsewhere. By 1967, the nation had lost 7.7% of its wetland habitat and, more recently, it was estimated that 23% of United States estuaries had been severely modified, and 50% had been moderately modified (La Roe 1977). These impacts have not been uniform as some states have experienced disproportional losses (e.g., 67% of California's estuaries have been destroyed).

Although dredging activities can have disastrous effects on wetland ecosystems, not all effects have been totally detrimental. Today more than 2000 man-made spoil islands dot the U.S. coastal and inland waterways (Soots and Landin 1978). Many of these islands have become significant breeding habitats for wildlife, most notably for colonially-nesting waterbirds. An estimated 2 million waterbirds nest on dredged-material sites, mostly along the Atlantic and Gulf coasts. As the dredged-material islands develop vegetation, they sometimes offer alternate nesting habitats similar to those found where industrial and other developments have destroyed natural systems.

In sum, however, dredging was once largely indiscriminate and without measured impacts on a wide array of wildlife and delicate ecological systems potentially affected. Cost-benefit ratios almost routinely omitted the ecological dislocations incurred when dredging was proposed, and any fortuitous outcomes (e.g., man-made islands) were random and unplanned. Only recently have systematic studies of plant succession and the related nesting requirements of seabirds been described for management purposes (Parnell et al. 1978, Soots and Landin 1978), and a useful summary of dredging impacts on birds and other wildlife was compiled by Allen and Hardy (1980).

Besides dredging, coastal environments are also vulnerable to other development or development-related activities (e.g., oil, thermal pollution, waste disposal and urbanization). From 1960–1974, U.S. offshore oil production increased from 4% of the total to 16.3% (Clark et al. 1978). Within the next 15–25 years, offshore petroleum may account for 40–50% of all domestic production. Major offshore areas include the central Gulf of Mexico, Gulf of Alaska, west Gulf of Mexico, southern California, Mid-Atlantic, east Gulf of Mexico, North Atlantic, Bristol Bay and Beaufort Sea. Effects on the onshore environment, piers, bulkheads, beach stabilization, roadways and bridges, housing, schools, recreation, etc., will be substantial (Zinn 1978).

Thermal pollution from nuclear facilities (4000 coastal nuclear parks are proposed by Weinberg and Hammond 1970) affects reproductive cycles and growth in plants and alters composition of fish communities. Effects on bird communities are relatively unknown, al-

though bird-species diversity decreased following intense thermal loading of an inland wetland in South Carolina (Gibbon and Sharitz 1974). The installed capacity of nuclear plants is expected to increase from 53 gigawatts in 1978 to 207 by the year 2000. Nineteen plants are licensed to operate on or near the coast, 15 are under construction, and 11 are planned.

Combustion of fossil fuels with high sulfur content has increased the acidity of precipitation in the northeast. A two- to five-fold increase in metric tons of sulfur oxides is projected by the year 2000 (Cavender et al. 1973). Effects include regional decreases in numbers and species in fish and invertebrate populations and a reduction in forest growth. Effects on birds again are largely unknown, but decreases in invertebrate food resources may be a factor in the survival of juvenile Black Ducks (*Anas rubripes*) in coastal marshes (J. R. Longcore, pers. comm.).

Waste disposal (industrial, agricultural and urban) is projected to affect 86% of nearly 700 coastal U.S. estuaries in 1980; most seriously affected will be the Chesapeake Bay and those along the South Atlantic Coast, Florida and the Gulf Coast (U.S. Dept. of the Interior 1970). Problems associated with components of agricultural or industrial pollution—DDT, DDE, dieldrin, polychlorinated biophenyls, kepone, lead, cadmium, mercury and others—clearly involved birds in recent decades. In sum, between 70–80% of the U.S. population will live near coastlines in the 1980's (L. Shank, pers. comm.), emphasizing the need for coastal zone management.

The Migratory Bird Treaty Act (1918) is one of four major legislative acts affecting birds and coastal management. Two cases, the U.S. vs FML, S72 F 2d 902 (2d Civ. 1978) and U.S. vs Corbin Farm Service, 444 F. Supp. S10 (E.D. Cal. 1978) affirm the protection of migratory birds from toxic pollutants, even without the intent or knowledge of the actor. Further, U.S. vs Brown, S22 F 2d 817 1977 permits Congress to enact legislation protecting federal lands from "spill over" effects of activities occurring on nearby non-federal public lands or waters.

Congress enacted the Coastal Zone Management Act of 1972 to establish a voluntary federal-state partnership for management of coastal resources. The Act encourages coastal states to participate in the development and implementation of comprehensive coastal management programs. By the end of 1979, 75% of the U.S. shoreline came under federally-approved state coastal zone management programs (Speth et al. 1979). These operate to minimize the destruction, loss, or degradation of wetlands and flood plains including those within the coastal zone. However, unsettled interpretation of the statute has lessened joint planning for coastal zones among federal and state agencies (Dedman 1979), and to date, Congress has not reauthorized federal assistance to state coastal zone management programs.

The Fish and Wildlife Coordination Act (1934) required that federal agencies give full consideration to wildlife in major water development projects. Although historically ineffective, the Act, strengthened by a presidential water policy memorandum issued in July 1978, now mandates consideration of: (1) measures to conserve wildlife, (2) alternatives to the project and (3) the implementation of conservation measures.

The fourth act is the Endangered Species Act of 1973, as reauthorized for three years in 1979. At least 27 endangered species of birds breed or have migratory areas in coastal zones (Woodard 1980). Determining critical habitat for these species, however, requires consideration of myriad economic and ecological issues.

Petroleum Discharges and Oiled Birds.—The most publicized oil spills are tanker accidents or offshore platform blowouts, but millions of tons of petroleum also enter the marine environment annually from a variety of other sources (National Academy of Sciences 1975, American Institute of Biological Sciences 1976). Approximately one-third of the total petroleum entering the sea is introduced as a result of transportation activities, of which tanker accidents comprise only a small part. River and urban run-offs account for another third of the petroleum entering marine environments. The remainder comes from coastal oil refineries, offshore production, natural seeps, atmospheric fallout and other minor sources.

Crude oil and oil products are composed of thousands of aliphatic and aromatic compounds, each possessing its own set of physio-chemical characteristics (Lee 1977). Some compounds are more toxic to aquatic organisms than others; some are more soluble than others and rapidly enter the water column and contact organisms. For example, No. 2 fuel oil, which contains toxic and soluble hydrocarbon compounds, is likely to have a greater impact on organisms than No. 6 bunker fuel, which has fewer highly toxic or soluble compounds (Nadeau 1977). Thus, the effect that an oil spill has on a marine environment is influenced by a number of factors: type of petroleum, volume spilled or released, hydrography of the affected area, climate, treatment methods, previous exposure of the affected area to petroleum releases and habitat type.

Avian mortality resulting from petroleum spills was reported as early as 1910 (Bourne 1968). It was not until 1967, however, when the Torrey Canyon accident occurred and an estimated 40,000–100,000 seabirds died, that the problem of oil-induced mortality became widely recognized (Bourne 1970). Many birds, particularly those species that spend a great deal of time in the water, are coated with oil and die from exposure when the insulative properties of their plumage is impaired. Oil also can be directly harmful when birds feed, drink, or preen; indirectly when consumed through food chains, or when applied to eggs by incubating adults. The literature dealing with toxicity of ingested oils and oiled eggs has been reviewed by Albers (1977) and Eastin (1979).

In other areas of the world, particularly in Europe and South Africa, oil pollution is believed responsible for a steady decline in seabird populations. With the current and projected demands for energy in the United States and with increased tanker traffic and accelerated development of offshore petroleum reserves, oil spills and oiled birds will become more common in our waters. In more than 100 oil spills studied throughout the world between 1960 and 1971, approximately 20% involved 50 birds or more (Ottway 1971). However, estimates of avian mortality in any oil spill may be far lower than actual mortality—deaths at sea may be 6–25 times more than the number washed ashore (Tanis and Mozer-Bruyns 1968).

Although the effects of oil on birds are the subject of much current research, few investigators have examined the results of oil spills on bird populations and their habitats. In most cases, reliable pre-impact estimates for the affected populations are scarce (Bourne 1968, Vermeer 1976), and population data on food-chains are virtually non-existent. For example, oil-contaminated sediments almost certainly have residual toxicity to invertebrate populations, and oiled hard-surfaces (e.g., rocky seashores) are not colonized easily by attaching organisms (Nadeau 1977), all potentially affecting the avian carrying capacity of an oil-impacted area.

Although the "state of the art" for cleaning oil-soaked birds has improved considerably since the Torrey Canyon disaster, birds still cannot be rehabilitated in biologically significant numbers (Williams 1977). Only a small percentage of oil-soaked birds are ever captured and brought to cleaning centers; many more that are oiled at sea never reach shore (Tanis and Mozer-Bruyns 1968, Hope-Jones et al. 1970) and still others come ashore in remote and inaccessible sites (Chapman 1981). For these reasons most recent attention has focused on deterring birds from visiting areas of oil contamination (Ward 1977).

Unfortunately, most oiled birds cannot be captured easily until they have become somewhat debilitated by oil toxicity, exposure, or starvation. Therefore, by the time that a bird reaches a treatment center, the odds for survival are already low. The success of rehabilitating an oiled bird depends upon many factors: the toxicity of the oil, the degree of plumage fouling, weather conditions to which the oiled bird is exposed, the time elapsed between oiling and treatment, the condition of the bird prior to oiling and the species involved. Of equal importance are the presence of trained personnel and the availability of appropriate equipment, supplies and facilities.

Procedures for cleaning and rehabilitation of oiled birds have been detailed by Williams

(1977, 1978). Upon capture, the initial treatment includes: (1) the removal of oil from the nostrils and mouth to prevent further oil ingestion and to permit unhampered breathing; (2) tube-feeding a warm solution of 2–5% glucose in fresh water to provide hydration and energy; (3) taping the beak shut to prevent preening and oil ingestion; (4) wrapping the bird in cloth to reduce movements and to provide insulation; and (5) putting the bird in an individual box (placed in a quiet sheltered area) for transport to a rehabilitation center.

After arrival at the center, each bird is tube-fed additional hydrating solution, weighed and banded; an oral temperature measurement is recorded. Birds with temperatures below 38°C should be held under a heat lamp producing ambient temperatures of 29–32°C. Cleaning of a bird should not commence until its body temperature approaches the normal range of 39°C.

A solvent such as Shell Solvent 70 is generally recommended for cleaning heavy viscous oils, for large birds and for cleaning large numbers of birds; detergent is recommended for small birds (Williams 1977). Care must be taken to avoid damage to feather structure. After cleaning, each bird should be dried thoroughly with hot air and kept in individual, warm pens with abundant food and water.

Cleaned birds are kept in pens until they are free from all injury and damage, capable of swimming without loss of water-proofing and are in physical condition adequate for survival in the wild. During the rehabilitation process, which may take many months, the bird must be kept free from stress. However, force-feeding is sometimes necessary during the first few days of captivity.

In most cases, mortality rates during the cleaning and rehabilitation process are high. Probably the highest success rate (41%) has been maintained by the International Bird Rescue Research Center (IBRRC, 2701 Eighth Street, Berkeley, California 94710). However, few coastal areas presently have the equipment, expertise or facilities necessary to properly clean and rehabilitate oiled birds and, as a result, most oiled birds succumb to the toxic effects of the oil, exposure or shock (Smith 1975).

Oiled-bird rehabilitation can be expensive. In the 1971 San Francisco oil spill, approximately $900 was spent per successfully released bird. During that spill 95% of the birds died in captivity. More recently, however, the IBRRC reduced costs to $15 per successfully released bird. It is not known how well rehabilitated birds survive after release. Of 218 banded birds released after treatment following the San Francisco spill, 14 were recovered dead within a few months but several were recovered up to two years later and 1046 km away (Hay 1975).

National Estuarine Sanctuary Program

The Coastal Zone Management Act of 1972, as amended in 1976, authorized a series of nationwide estuarine sanctuaries. Section 312 charged the Department of Commerce to award 50% matching grants to coastal states for their acquisition, development and operation; the sanctuaries would be owned and managed by the states.

The primary purpose of the National Estuarine Sanctuary Program is to provide long-term protection for natural areas so that they may be used for education and research. Within each sanctuary certain alterations such as dredging, filling, bulkhead construction, expansion of existing channels, creation of new channels and alteration of water circulation patterns will be prohibited. However, public use for recreation, sport and commercial fishing, hunting and wildlife observation would be permitted as long as the activities did not permanently alter the natural system or detract from its educational and research uses.

The research value of such protected areas cannot be overstated. Undisturbed estuaries permit studies of naturally-functioning systems for comparisons with disturbed areas. Clear-

ly, the protection of these sites will be invaluable for birds and other estuarine-dependent biota.

At least 20 protected estuaries were chosen to represent all geographic regions (for the purposes of the program, estuaries was defined intentionally to include the estuarine-like areas of the Great Lakes). At present, seven National Estuarine Sanctuaries are in operation. The benefits of this program will accrue to not only the coastal region where the sanctuary is located, but also to the entire nation.

Recommendations

Based on the barrier-island protection plan (Dept. of Interior 1979) and a review of statements provided by a number of conservation organizations, the following recommendations focus on actions required to maintain and improve the management of aquatic and terrestrial habitats associated with barrier islands. Individuals and organizations with a deep interest in populations and habitats of birds and other natural resources have a unique opportunity to help perpetuate these resources.

(1) Request Congress, and indeed all levels of government, to recognize fully the special ecological and biological characteristics of barrier islands and their associated habitats; and to provide a coordinated, consistent policy and appropriate planning procedures to avoid degrading, destructive and inappropriate developments. Procedures should identify means by which proposed developments can be designed to remain consistent with conservation objectives and natural resource functions and values.

The need for new ways to handle barrier islands is emphasized by a cumulative and tangled record of activities and jurisdiction; nearly 20 federal agencies have programs that impact barrier islands. One-quarter of these agencies administers programs that directly or indirectly protect barrier islands. Nonetheless, more than one-half of them administer grant, loan, permit and construction programs that have fostered adverse impacts. Another one-quarter administers property, insurance and disaster relief programs that encourage or perpetuate unwise use of these fragile, dynamic landscapes. In the past three fiscal years alone, nearly a half-billion taxpayer dollars have been committed to barrier-island developments, many of which were incompatible with the islands' physical, ecological and biological characteristics.

(2) Support the conservation concepts embodied in bills (H. R. 857 and S. 96) pending in Congress. These bills seek to establish a barrier-island protection system. The objective is to improve maintenance and management of the unique natural, ecological and biological values of barrier islands. Federal subsidies would be cut off for developing these unstable, storm-prone areas, thereby minimizing risks and threats to human life and property, while simultaneously perpetuating wild living resources—including bird populations and their habitats.

As part of its coastal barrier-island inventory, the U.S. Fish and Wildlife Service has identified in "concept plans" nearly 50 barrier islands along the Atlantic and Gulf coasts that have exceptional value for fish and wildlife. Key congressional committees handling the barrier-island bills should be urged to provide that the islands identified on the Service's list, if ultimately acquired by the federal government, be administered by the U.S. Fish and Wildlife Service as units of the National Wildlife Refuge System.

(3) Focus special attention, with research and other educational programs, on barrier islands and other coastal habitats where birds and other forms of plants and animals serve as indicators of environmental health. In particular, the National Estuarine Sanctuary sites offer functional control areas for many types of research that may act as biological cornerstones for desirable legislation and protection in the future. Pristine or near-pristine coastal environments are rarities that, with study, may stimulate the orderly recovery of already-

degraded sites elsewhere. Among the many opportunities is work dealing with densities of birds and their dependent ecological requirements in undisturbed coastal habitats. The plethora of real or potential abuses, particularly those related to petroleum extraction, suggests that ornithological activities on coastlines will be especially desirable in the coming decade.

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This issue of *The Wilson Bulletin* was published on 29 October 1981.